Organic nano-grains in comet 103P/Hartley 2: The organic glue of porous aggregate grains?

D.H. Wooden, NASA Ames Research Center

Co-Authors: N. Dello Russo, A. Li, C.E. Woodward, M.S. Kelley, D.E. Harker, J.C. Cook, R.J. Vervack, T.R. Geballe

The GNIRS instrument on the Gemini 8-m telescope observed comet 103P/Hartley on 2010-Dec-04UT, a month after the EPOXI Mission encounter (A'Hearn et al. 2011), and detected the 3.3 and 3.4 um bands in emission (Wooden et al. 2011, 2013). The 3.3/3.4 ratio and the broad band widths are consistent with experiments of heated (~600 K) aliphatic carbon (–CH3, –CH2) thin films (Dischler et al. 1983). For the 3.4 um band to be in *emission*, the aliphatic bonds must be attached to a carrier possessing the strongly UV-absorbing C=C aromatic rings, and these rings have to be less than 50-100 carbon atoms (4–6Å) for attached –CH bonds to also generate a 3.3 um band in *emission* (Fig. 2) (Schutte et al. 1993). Slightly larger (≥10Å) Very Small Grains (VSGs) can absorb single UV photons comparable to or exceeding their heat capacity, thermally fluctuate and release IR photon(s). The 3.3 um and 3.4 um bands observed by GNIRS suggest that organic macromolecules/ nano-grains with both aliphatic and aromatic bonds are fluorescing/thermally fluctuating in the coma. Aliphatic and aromatic materials have been seen in Stardust samples and the primitive carbonaceous chondrite 'Tagish Lake'. The larger the ratio of the –CH2/–CH3 components of the aliphatic 3.4 um band, the more 'primitive' the organic material (Matrajt et al. 2013). In a Stardust organic globule, some aliphatic bonds were transformed into aromatic bonds during the low dosage of Transmission Electron Microscope imaging (De Gregorio et al. 2010). Conversely, lab experiments show irradiation of ices containing small PAHs generates aliphatic organics. Photo-processing of ices also likely forms the ubiquitous aliphatic coatings that appear on the surfaces of all silicate subgrains constituting nine cometary interplanetary dust particles (Flynn et al. 2010a, 2010b, 2011). The aliphatic coatings, dominated by –CH2, likely were important in sticking the aggregates together, and existed prior to incorporation of dust aggregates into comet nuclei. These comet aliphatics may be some of the sought-after precursors to the more robust and complex organics studied as Insoluble Organic Matter in carbonaceous chondrites. Aliphatic coatings on submicron grains, however, will not be observable in absorption because they are fairly transparent, nor do the aliphatic carbonaceous coatings produce the 3.4 um emission band because the particles they are attached to are too large (too many vibration modes). We must probe the nano-sized organic carriers that undergo substantive thermal fluctuations in cometary comae and *emit* at 3.3 um and 3.4 um. Observations of the 3.3 and 3.4 um emission features contribute to characterizing the evolution of organics prior to their incorporation into cometary nuclei as well as their rapid evolution in cometary comae, which in turn contributes to deepening our understanding of the evolution of organics on the surfaces of asteroids and outer icy bodies in our solar system. Studying organics in comets contributes to understanding the formation and evolution pathways of ISM organics through to the formation of the robust insoluble organic matter in meteorites.

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